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NATURAL GAS BASED TECHNOLOGIES AS REVEALED IN POSSIBLE NEW ZEALAND ENERGY PROGRAMS

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INTRODUCTION

New Zealand is an exporter of commodities and thus completely dependent on world market conditions. Its large resources of hydro-electricity, forests, natural gas and fish give it the possibility of industrializing. The off-shore debt on March 31, 1982, stood at US $ 3,263 million or about US $ 1,052 per head of population - just about as high as the per capita debt of Argentina - a country mentioned when the world banking system started to worry about possible defaults. In the words of Foreign Minister Warren Cooper before the U.N. General Assembly on October 6, 1982 - "As a small trading nation, New Zealand is acutely sensitive to fluctuations in the health of our major trading partners. New Zealand is classed as a developed country, but we share many of the problems of developing countries".

New Zealand has no oil resources and when the country was hit by the Energy Crisis it decided to develop the gas fields at Kapuni and at Maui in the Taranaki province (in the western part of the North Island) in order to collect associated liquid condensates. The gas was first used to fire electrical plants and later readied for reticulation via pipelines in the Northern Island. Eventually, when the condensate became so much more valuable than the gas - despite its quantity being much smaller - it actually led to flaring the gas to waste in order to obtain the condensate. A "take-or-pay" system was negotiated under which the government is contracted to take a given amount of gas per year from the producing partnership. Assuming that future oil prices will rise only a few percent per year in real terms and performing a standard Discount Cash Flow analysis with a 10% discount rate, the conclusion reached was that there was a higher financial value to be obtained from using the condensate - leading to a zero value for the gas and to a financial justification for flaring it. On the other hand, the gas could be used 1) for reticulation, 2) for promoting a CNG industry (compressed natural gas) or 3) for use in petrochemical industries to produce chemicals or further liquid fuels. Following this logic, and attempting to produce the least change in the transportation system, the New Zealand Ministry of Energy went along with a plan to produce synthetic gasoline from what was then seemingly unwanted gas.

The present paper argues that it would be rather to the long range advantage of New Zealand for the Government to stop at the methanol stage and use methanol as a new liquid fuel in addition to CNG motor fuel rather than go all the way to produce the synthetic gasoline from natural gas.

A MISUSED INNOVATION

Mobil Research and Development Corporation laboratories in Paulsboro, New Jersey, developed spongy, shape-selective catalysts to promote a reaction that transforms alcohol into hydrocarbons by excising water molecules. The catalysts are different pore sized aluminum silicates or clays called zeolites (the Greek word for boiling stones - this because the ancient Greeks observed that certain stones when thrown into fire appeared to boil, thus indicating that the interior structure was hollow enough to contain water and that the pore openings were large enough to allow the water to escape). ZSM-5 is a synthetic zeolite whose uniform pore size and shape is such that when treated in a Mobil-developed process will make possible the chemical reactions involved in the elimination of water molecules from the methanol feedstock. (Z stands for Zeolite; S stands for Socony, and M stands for Mobil as "Socony" or Standard Oil Company of New York was an old name for today's Mobil Oil; 5 is a key for the class of the catalyst.)

When producing the hydrocarbons we define as synthetic gasoline, the catalytic process consumes 10-15% of the energy content in the methanol feedstock (1) but what should be remembered as equally important is that half of the <u>volume</u> of the liquid feedstock is lost when the water molecules are eliminated. Then, depending on how the fuels are used, if the energy content as measured in calorimetric units does not express accurately the work yield of the fuel vehicle engine, or if different fuels show different efficiencies when used in the same engine, the fact that we have lost half the volume may lead to serious differences in work yield. In other words, reducing the liquid fuel volume of the methanol to approximately one half in order to form the twice higher energy-content synthetic gasoline wastes advantages the alcohol has had per energy unit. This is where the most serious inefficiencies of the Mobil MTG (methanol-to-gasoline) process are incurred - more so than in the energy loss of the process itself (2).

The methanol for the Mobil process can be obtained by passing synthetic gas produced from coal over a copper catalyst or starting with natural gas. Mobil Oil has no proprietory technology for the production of methanol and in New Zealand it will be using an I. C. I. process and 40% of the natural gas feedstock energy content will be lost at this stage. The Mobil ZSM-5 catalyst's competing technology is a $ZnCl_2$ process that was also looked into by the New Zealanders when making their decision (3). To be sure, one does not expect difficulties in upscaling the Mobil MTG process from the four-barrels-a-day pilot unit in Paulsboro, New Jersey to the 13,000-14,000 b.p.d. plant at Motunui, New Zealand, and when completed the plant will most probably deliver as planned but then one could reasonably expect that besides not allowing for a maximum gain to New Zealand from the available natural gas resource, the influx of synthetic gasoline will create an amazing stress on the one and only petroleum refinery in New Zealand that will have to continue to operate on imported crude in order to provide the needed diesel fuel, leading to a future when New Zealand will probably have to import expensive petroleum crude and export cheap gasoline. New Zealand will be left in the process totally dependent on petroleum or "Petroleum-alike" fuels while losing the opportunity it had to move away from petroleum systems by using the natural gas as an entry to a gas and alcohol future to make the two New Zealand islands energy independent indeed. This goal cannot be achieved by providing fuels to existing systems, but rather by adapting its fuel uses to fuels available locally i.e. change its motor vehicle fleets to CNG and methanol cars and opening the future, by establishing now the appropriate end use to biogas, synthetic natural gas from coal, methanol from coal or peat and ethanol from biomass.

New Zealand in answer to its energy needs was destined to experiment with new energy development but it seemingly chose to stay with the old instead of going the way of true innovation. New Zealand, thanks to its geography can go it alone. By not having to worry about cross-border traffic it can isolate itself by going CNG and methanol before the rest of us do so (3).

THE PETROLEUM REFINERY

Petroleum refinery design is dictated by the needs of a relatively small number of products, e.g., gasoline, jet fuel, diesel fuel, fuel oil. It is generally recognized that the most important part of any refinery is its gasoline manufacturing facility. As the demand for gasoline increased, more and more of the lighter kerosene components were included in gasoline but the maximum suitable portion depended on the kind of crude oil and rarely exceeded 20%. As such, methods more and more complicated were developed to obtain further products that could be blended into the original gasoline fraction. The customary processing in a refinery is thus no more a fractionation process producing relatively pure hydrocarbons, but rather a very complicated system with flows into a general pool of products - the gasoline produced being a mixture of ingredients with different economic costs. Gasoline blending is thus the combining of components to make up the liquid defined by a given set of properties that enable it to be a fuel in a motor vehicle internal-combustion engine. One of the most important properties that must be satisfied is the required octane value. To produce higher octane ingredients that when blended with the first run low octane product, higher temperatures in cracking processes have to be employed. This more severe and energy intensive process, besides being more costly, as it requires higher energy inputs, also creates less valuable by-products - the upshot being that the economics of production at the refinery change. Furthermore, with the requirement to eliminate the octane boosting tetra-ethyl lead from the gasoline formulation because of environmental reasons some refineries, in most cases the smaller refineries, do not even possess some of the needed equipment for these processes.

Both methanol and ethanol when added at about 3% to low octane gasoline will enhance the gasoline's octane number by one point (that is the average over motor octane and research octane). With 10% of the alcohol the average octane value is improved by about 3 points and with 20% of the alcohol 5 points improvement of the average octane value is achieved. Detailed calculation for savings in petroleum crude, when using alcohol octane boosting additives to gasoline, were presented before the First European Communities Conference on Energy from Biomass (4-6). To recapitulate here - it was found that each Btu of ethanol used this way replaces 3.55 Btu of gasoline or one liter of ethanol replaces at least 2.5 liters of gasoline. Following a similar path one can calculate that when using 5% methanol as an additive to gasoline each Btu of methanol used this way replaces 4 Btu of gasoline or one liter of methanol replaces at least 2 liters of gasoline.

In order to calculate the effective energy balance (in the use as well as in the production of the alcohol) the above values have to be multiplied with the energy balance in the manufacture of the alcohol. For the case of biomass ethanol, using a factor calculated by Professor Melvin Calvin - 1.76 each Btu used as energy input in fertilizers, agricultural machinery or distillation equipment end up displacing 6.6 Btu of petroleum origin when the ethanol is used as an octane boosting additive to gasoline. When the ethanol is used instead as a fuel in an ethanol driven engine (no gasoline involved) in the effective use of the ethanol the potential gain at the refinery is lost. Also, the Btu content of the engine fuel that in the mixture is decreased only by about 3% will be decreased now by rather 30%, while the octane value of the fuel has been increased in the ethanol-alone case to a value higher than required by an unchanged engine. It is expected thus to decrease from the above calculated advantages for the case of the mixed fuels to net gains of only about 20% above the Btu content of the fuel; each liter of ethanol used replaces now only about 0.8 liters of gasoline and each liter of methanol used replaces only 0.6 liters of gasoline - this leading to higher savings in terms of petroleum resources, but also for economics much more difficult. This alternative becomes a possibility when political decision is taken to avoid dependence on petroleum crude. When mentioning alcohol-gasoline mixtures, despite the favorable results of the Brazilian program and many other programs, i.e., in the U.S., West Germany, South Africa, when a New Zealand journalist visited the Mobil Oil Paulsboro facility he was cautioned against such blends "as liable to cause too many technical and distribution problems". Considering that a second plant in New Zealand was built to produce methanol for export - this in a world market that is already saturated with methanol production capacity - Mobil that is already expected to supply one third of New Zealand's need for gasoline in 1985 suggests to use the additional output of methanol in its Motunui plant (7) thus resulting in a production of synthetic gasoline equal to over 50% of what could reasonably by expected to be the New Zealand need for gasoline by a conventional motor-vehicle fleet. Interestingly Shell and B. P., the other corporate partners of the New Zealand refining corporation, did not agree to participate in the Mobil Oil project.

POLICY ISSUES

The Marsden Point refinery used, in 1981, 2,300,000 tonnes of crude oil and 440,000 tonnes of gas condensate and produced 1,236,000 tonnes gasoline and 685,000 tonnes of diesel. After the expenditure of over 1 billion for expansion and for building a hydrocracker, the refinery will use 2,884,000 tonnes of crude and 816,000 tonnes of condensate in order to produce 1,050,000 tonnes of gasoline, 430,000 tonnes of aviation fuel, and 1,125,000 tonnes of diesel. This change at the refinery will also double the refinery fuel loss from 165,000 tonnes/year to 330,000 tonnes/year.

On March 31, 1980, New Zealand Motor Vehicle licenses amounted to 1,283,661 passenger cars, 3,134 taxicabs, 3,397 buses and coaches, 176,692 trucks under 2 tonnes, 76,872 trucks over 2 tonnes. When including all other vehicles such as motorcycles, and motor homes, a grand total of 2,157,516 motor vehicles were licensed. New registrations for the year 1981 amounted to a total of 114,842 cars, the majority of which were assembled in New Zealand from parts imported mainly from Japan (73%). Other important countries of origin were the U.K. with 13.6% and Australia with 11.1%. All other countries of origin, including the U.S., amounted to only 2.3% (nevertheless, when analyzing the manufacturing companies it is clear that Ford and General Motors are well represented, mainly through their Australian and U.K. affiliates, amounting to about 30%).

Two of the motor vehicle assembly corporations were responsible for over 21,000 vehicles each while four other corporations were in the 10,000-18,000 range. Thus it is reasonable to assume that a corporation that may not even produce a CNG or methanol car for its own home market may find it advantageous to send such kits to the New Zealand assembly plant. In effect it would just take the cooperation of two such corporations in order to embark on a slow process of changing the motor vehicle fuels system gradually. The funds for such changes could then easily be found from the $1.5 billion that could be saved by eliminating some changes at the refinery and by eliminating the methanol-to-gasoline stage at the Motunui plant (8).

It is preferable to go to dedicated vehicles - vehicles that were originally built for non-petroleum fuels use - rather than convert vehicles that were originally built to use gasoline fuels. Such conversions, for the CNG case, leave the vehicle with an undesirable seriously decreased trunk space.

CONCLUSIONS

The Mobil MTG process, to be employed in New Zealand, is being scaled up from the Mobil Oil Paulsboro operation to what could be a commercial size plant. Nevertheless, the economics in the New Zealand case are such that this operation can only prove the technical aspects of the plant but not the economics - the New Zealand economics being figured out on the basis of a practical give-away of the natural gas.

Furthermore, New Zealand being a set of two islands with very little traffic from the outside, could have switched to a transportation system based on CNG and methanol with an intermediary stage that uses the existing Whangarei refinery, without changes, and methanol for an octane enhancer. Such a policy besides having environmental benefits is economically sounder in the long range as 1) it allows for a much larger energy efficiency for the natural gas resource and 2) it prepares the economy to an eventual switch to other sources of fuel gas and alcohols. New Zealand has large potential for the production of biomass and has as well coal and peat deposits that will eventually form the basis for an industrialization of the South Island. The elimination of the dependence on a petroleum system and the development of an indigenous industry are, reasonably, the real long range interests of New Zealand.

What was said here is in no way an expression of doubt in the technical feasibility of the Mobil MTG process. It is highly possible that for other countries, and in other objective circumstances, this process can be applied in accordance with national interests. Such circumstances could be envisioned for example for the case a country cannot isolate itself when its roads are being used or by cars originating in areas that would not participate in a policy of switching from petroleum fuels.

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